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POTATO-TUBER DISEASES.

BY

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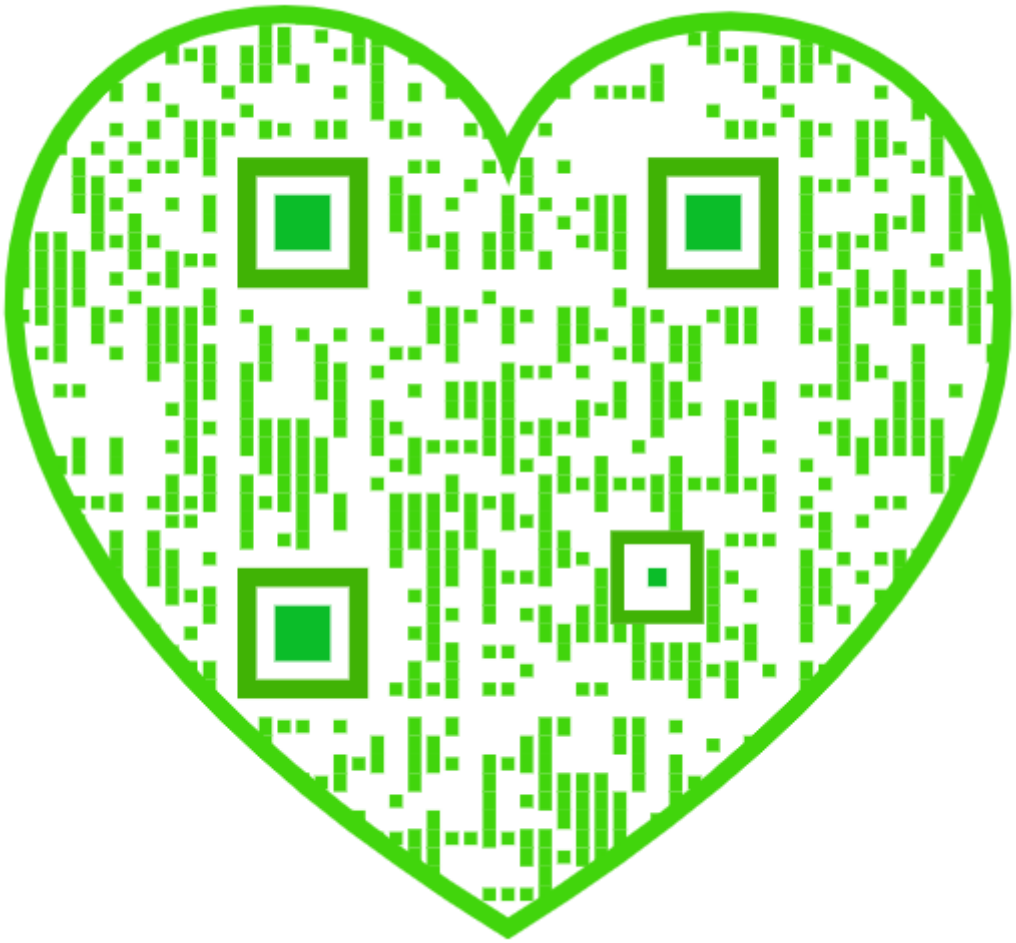

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., April 10, 1913.

SIR: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a manuscript entitled "Potato-Tuber Diseases," by Mr. W. A. Orton, Pathologist in Charge of Cotton and Truck Disease and Sugar-Plant Investigations.

The increasing prevalence of potato diseases and the extent to which these are carried over on seed makes it desirable to present information regarding methods of control as a basis for a campaign for the use of disease-free seed potatoes.

Respectfully,

WM. A. TAYLOR,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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POTATO-TUBER DISEASES.

INTRODUCTION.

The average yield per acre of potatoes in the United States is not more than half what might reasonably be expected. This shortage is attributable to a variety of causes, including numerous diseases, a lack of well-adapted varieties, failure to fertilize liberally and to cultivate intensively, and neglect of crop rotations. The fact that in several States the long, hot summers are unfavorable for potato culture also tends to lower the average production of the country.

Potato diseases constitute an exceedingly important factor in American potato culture and require every grower who aims toward a high standard to exercise the closest watchfulness, not only at the time of planting and throughout the growing season, but at the harvest and during the winter storage. The use of disease-infected seed is one of the principal causes of failure to germinate, and poor stands are responsible for many low yields; other diseases introduced in seed injure or kill the growing plants; scabby, deformed, or otherwise affected potatoes bring a lower price in the market; losses in storage or in transit result from infections by decay-producing organisms. New troubles are constantly being introduced from foreign countries on imported potatoes. They effect a lodgment in one of our seed-producing districts and are thence distributed to all parts of the country. Our soils thus become infected and are permanently or for several years thereafter rendered less suitable for potato production.

At no time is there a better opportunity to improve the quality and increase the quantity of the potato crop through prevention of disease than before planting. This bulletin directs attention particularly to those troubles affecting the tubers or carried on them which should be taken into consideration in selecting the seed stock for planting.

There are peculiar conditions in the United States which make this a subject of wide and general interest. A large part of our territory lying in the Southern, South-Central, and Western States secures

better results from planting seed potatoes grown near our northern border in Maine, New York, Minnesota, etc., than from home-grown stock. There has consequently grown up a large trade in potatoes which are annually shipped long distances for planting.

Furthermore, there is taking place a constant extension of potato culture into districts where this crop has not previously been grown. This development is most notable in the newly irrigated parts of the West, in the recently deforested portions of Minnesota, Wisconsin, and Michigan, and in the trucking districts of the Gulf States. In each case the seed supply has to be brought from outside, and in far too many cases no attention is paid to the elimination of disease. That it might be practicable to keep these new soils free from infection by rigid exclusion of diseased stock is not realized in time. Few growers and few communities profit from the experience of others, but must be convinced by personal losses. The opportunity of keeping a district free from infection will not come again, for most diseases remain for considerable periods in the soil and are not easily exterminated. Furthermore, the principal potato troubles have already been widely disseminated.

The responsibility of seed dealers in this matter is large. The interest of the local dealer in the continued maintenance of productivity of a region is as great as the farmer's, and few of them would knowingly risk the introduction of pests that might threaten the prosperity of their section, yet through lack of foresight and knowledge this has often been done.

THE PRINCIPAL DISEASES AND THEIR CONTROL.

There are several minor diseases of the potato tuber that are not discussed in this bulletin. Some insect injuries, also, are not infrequently confused with the diseases, but, in the main, the troubles which the potato grower should know and watch for in selecting seed are included. No attempt has been made to treat each trouble fully or to give technical details, but a description has been given, which, taken in connection with the illustrations, should make the recognition of each disease a simple matter. The most successful means of control are outlined. At the end of the bulletin (p. 14) is a general discussion of seed inspection, disinfection, and methods of growing and distributing healthy seed potatoes.

DISEASES AFFECTING THE SKIN OF THE TUBER.

More or less superficial injuries are caused by several scab organisms, parasites of the periderm and outer layers. A discussion of the most important follows.

Common Scab.

Common scab, a widely prevalent and familiar disease, is caused by a parasitic organism previously considered a low type of fungus (*Oospora scabies* Thax.), though more recent work indicates that it is more closely related to certain soil-inhabiting bacteria. It produces rough, scabby, or pitted spots on the potato (fig. 1), which may spread and cover the whole tuber. They are sometimes made deeper through the work of small insects. Beets and turnips are also occasionally attacked.

FIG. 1.—A potato affected with common scab.

This parasite appears to be present in many soils and to be able to live there for years, particularly if the land is not acid. It is believed that the planting of infected potatoes is the chief agency of spread. It is therefore recommended that all seed stock be disinfected before planting by soaking two hours in a solution of formaldehyde (1 pint to 30 gallons of water). This treatment should be given whether any scab is detected or not, as the infection may nevertheless be present. Slightly scabby potatoes are not objectionable for planting if disinfected, but very scabby ones are usually rejected, as the eyes may be affected. Treatment of seed will not be sufficient if the soil is infected with the scab fungus; a long rotation of other crops then becomes necessary.

FIG. 2.—A potato affected with russet scab, showing the russeting and cracking, associated with the fungus Rhizoctonia, of a western potato.

Scab requires a neutral or alkaline soil reaction for its best development. It does not occur on distinctly acid soils unless an alkaline fertilizer is used. Lime, fresh stable manure, and wood ashes all promote scab, so these materials should not be used on the potato crop. Whether they can be applied

to another crop in the rotation depends upon the degree of acidity present, which can be ascertained only by actual field experiments or by having the lime requirements of the particular field in question determined by chemical tests. If used at all, it is advisable to apply them to the crop immediately following potatoes in the rotation system.

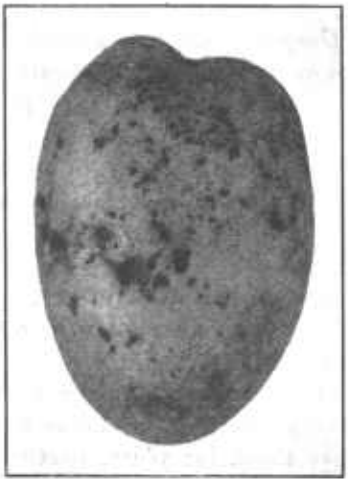

FIG. 3.—Black resting bodies, or sclerotia, of Rhizoctonia on a potato.

Acid soils may yield clean crops from scabby seed, but if they are later made alkaline by lime or manure scab may develop. The use of commercial fertilizers, especially those containing chlorids, such as kainit or muriate of potash, tends to bring about an acid condition of the soil. Plowing under green crops like rye has been recommended as an expedient for reducing scab injury in infected soils, but experiments have shown that this is not always effective.

Russet Scab.

A second form of scab, or russeting, on potatoes, which is common in the West, is shown in figure 2. This is attributed to the sterile fungus Rhizoctonia, but has not yet been well worked out. It often occurs in association with the common scab. The fungus is conspicuous for its brown mycelial strands and black sclerotia, which appear on the outside of the tuber, as in figure 3, where no direct injury to the potato has resulted and the black bodies can be scraped off. Such fungous masses are so common that it is sometimes difficult to find seed stock entirely free from them. Heavily spotted potatoes should not be planted. A second stage of this fungus occurs as a white, felty covering on the bases of potato stalks in late summer.

FIG. 4.—A potato affected with powdery scab.

This fungus appears to act as a parasite mainly in heavy, poorly aerated, or overirrigated soils. It is the cause of seedling troubles

of many plants, including cotton, beets, and beans, and may cause lesions on the potato stem at the soil line and below. If girdled, the plant forms numerous aerial potatoes. If the lesions are on the stolons the small potatoes are cut off, and large vines with small and few tubers result. This trouble is more common in irrigated districts than in the East.

This disease is not to be combated by seed disinfection, as the black sclerotia of the fungus are not killed by the ordinary for-

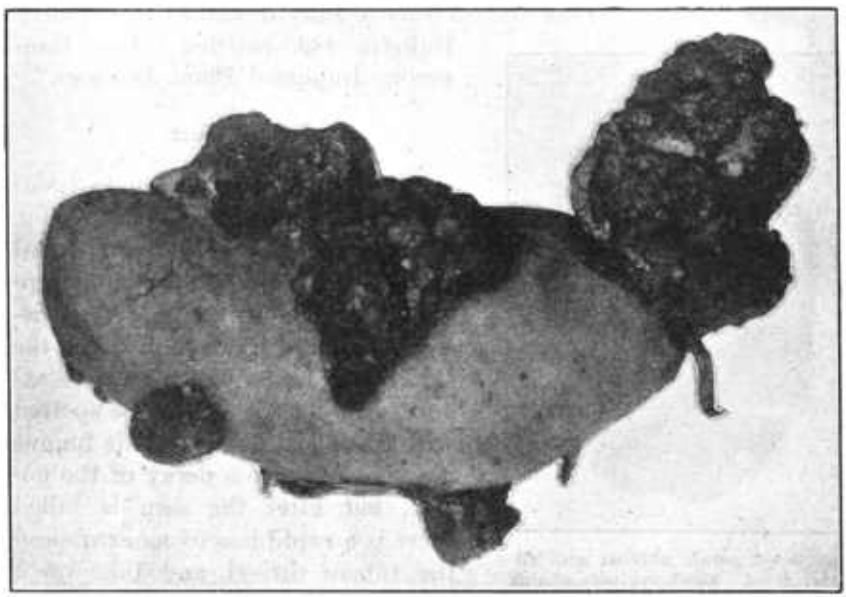

FIG. 5.—A potato affected with potato wart. (From Journal of Board of Agriculture.)

maldehyde treatment. Selections of lighter types of soil, rotation of crops to add humus, and deep preparation and culture to maintain a good physical condition of the soil are important.

Powdery Scab.

Powdery scab, a new type caused by a parasite (*Spongospora solani* Brunch.) quite different from that causing the common American scab, has recently been introduced from Europe into Canada and may be found in this country. This differs from the common scab in the character of the spots, which are first covered and later break out into brown, powdery masses. (Fig. 4.) In many cases this disease forms swellings or excrescences on the tuber. Since it is likely that this will prove to be a quite serious disease it should be carefully watched for and promptly reported.

Potato Wart.

Among threatening diseases not yet introduced, but which should be watched for and reported by American growers, the potato wart (*Synchitrium endobioticum* Perc.)[1] is the most serious. This forms irregular, warty excrescences on the tubers (fig. 5), sometimes entirely destroying them. The importation of potatoes from countries where this disease exists has been prohibited, but, unknown, it may already have gained a foothold somewhere. Any suspected case should be reported. This disease is more fully described in Farmers' Bulletin 489, entitled "Two Dangerous Imported Plant Diseases."

FIG. 6.—A potato affected with silver scurf. The lower part of this tuber is affected; the upper, normal.

Silver Scurf.

A new disease, silver scurf (*Spondylocladium atrovirens* Harz) (fig. 6), has recently been introduced from Europe and is spreading rapidly in our Eastern States. This disease is marked by dark areas on the skin of the tuber, which on close examination may be seen to be spotted with fine black points. This fungus does not produce a decay of the potato, but after the skin is killed there is a rapid loss of moisture and the tubers shrivel and take on a silvery appearance, greatly depreciating their market value. This fungus is apparently not killed by seed disinfection; therefore all infected potatoes must be rejected.

DISEASES OF THE STEM AND VASCULAR SYSTEM.

Black-Leg.

A serious disease of the potato plant, which can be controlled by seed selection and treatment, is black-leg. This is marked by the upward rolling and yellowing of the young or half-grown plants and by the black, shriveled condition of the stem, from the seed piece to above the ground. (Fig. 7.) The cause is a bacterial organism (*Bacillus phytophthorus* Appel and related forms), carried in the seed potatoes. An extreme case of a tuber affected with black-leg is

[1] This disease is also known as potato canker and black-scab.

shown in figure 8. Others may show only a browning of the vessels at the stem end.

Black-leg apparently came to us from Europe. It is spreading in the Northern States, but is of especial consequence to the southern trucker, as it takes a more virulent form in the South. Growers of seed potatoes should take every means to eliminate black-leg from their fields, and southern purchasers should insist that this be done. Dr. W. J. Morse, of the Maine experiment station, in 1911 advised that all bruised and cracked tubers be rejected when planting and that the selected stock be treated as for scab. He said:

> Those who were intending to plant only selected, treated seed were advised to reject all tubers when cutting which showed any discolored areas in the flesh, particularly those which showed browned or blackened rings at the stem end, no matter how slight. As a further precaution it was recommended that extra knives and a jar of formaldehyde solution be provided when cutting seed and if, by chance, a diseased tuber was cut, the knife blade could be dropped into the disinfecting solution for a time and another used in its place.[1]

The seed should not be cut until immediately before planting and must not be allowed to become contaminated after treatment.

FIG. 7.—A potato plant affected with black-leg in the summer stage, the result of planting diseased tubers. The lower part of the stem is shriveled and black; the leaves are yellow and rolled upward.

Fusarium Wilt.

A brown or black discoloration of the stem end of the tuber when cut across, one-fourth to one-half inch deep, should condemn it for planting. Several diseases infect the stem end in this way, but perhaps the most serious is the Fusarium wilt. Potatoes showing the stem-end discoloration characteristic of this disease are shown in figure 9. The fungus causing this wilt (*Fusarium oxysporum* Schlecht) enters the plant through the small roots and works upward in the wood vessels, which are so filled that a wilting or premature death of the plant results. It overwinters in the tubers and

[1] Maine Agricultural Experiment Station Bulletin 194, p. 208, 1911.

has been widely spread by the use of infected seed, particularly in the Central and Western States, where it has caused great reductions in yield. Potatoes from wilted plants are more subject to the stem-end dry-rot mentioned on page 12. It is advised that no lot of potatoes be planted any material number of which show a deep brown or black discoloration at the stem end. Cases may be cited where such seed gave a satisfactory yield, but the land was thereby infected and in the end will become unproductive from this cause.

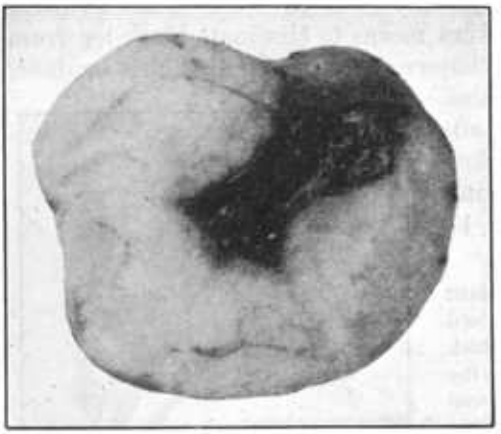

FIG. 8.—A potato affected with black-leg, showing decay starting from the stem end.

Verticillium Wilt.

A wilt disease somewhat similar to Fusarium wilt is caused by another fungus (*Verticillium alboatrum* Reink. and Berth.). This is marked by a stem-end discoloration of the tuber blacker than that of the Fusarium wilt, by a more rapid wilting, and by a geographic range more to the north. The wilted plants are conspicuous enough in the field to make it practicable to dig and destroy the affected hills during the summer. All affected tubers should be rejected for planting.

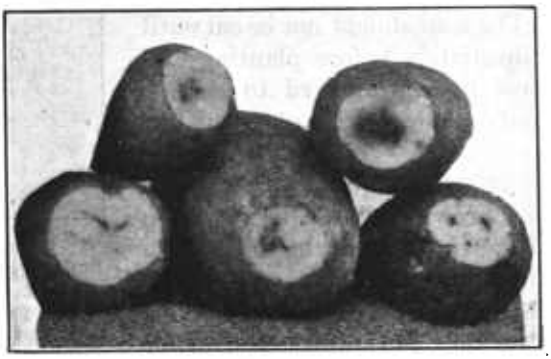

FIG. 9.—Potatoes affected with Fusarium wilt, showing stem-end discoloration of the vascular ring.

Bacterial Wilt.

In the South Atlantic States from Florida to Maryland a bacterial wilt is not infrequent. This parasite (*Bacterium solanacearum* Erw. Sm.) also attacks tomatoes, eggplants, and peppers. The foliage wilts suddenly. The wood vessels of the stem are discolored, and the potato shows a dark ring and usually decays quickly.

(Fig. 10.) When this disease occurs in the fall crop the product should not be used for planting purposes. No other practical method of control has been worked out. Since nearly all the southern crop is grown from seed obtained from northern sources, where bacterial wilt does not occur, the disease is not often a serious factor in commercial potato production.

TUBER ROTS.

Late-Blight Dry-Rot.

One of the most destructive diseases in the New England and North-Central States is the late-blight, due to a fungus (*Phytophthora infestans* De By.) which destroys the foliage in seasons of cool, moist weather. This is followed by a rot, marked by sunken, dark spots on the tuber (fig. 11) and by a brown discoloration of the flesh extending in from the outside (fig. 12). Under storage conditions this is typically a dry-rot, but in the field it more frequently becomes a soft rot, because other organisms follow the late-blight fungus.

FIG. 10.—Potatoes affected with bacterial wilt, showing wilting of stem and leaves and browning of tubers.

Affected potatoes should be discarded in planting, because they generally fail to germinate. This disease is a common cause of broken stands in potato fields. Late-blight is preventable by thorough spraying during summer and fall with Bordeaux mixture. This spraying should be especially well done on fields intended for seed purposes, for the potatoes become infected with dry-rot by spores from the blighting foliage at or before the harvest. This infection is often not apparent when the potatoes are put in storage, but it develops during the winter unless the temperature of the cellar is kept just above the freezing point. Cool storage is consequently a vital factor in the preservation of seed potatoes in seasons when late-blight is prevalent. The disease may develop on potatoes shipped south in the fall for seed purposes, unless the best of storage conditions are provided.

The presence of late-blight dry-rot on the potatoes planted is thought to promote the early appearance of the foliage blight the next summer, provided the cool, moist weather required for its development occurs. The disease is thus carried to the South Atlantic trucking districts and develops as leaf-blight during the spring, whereas in the North it prevails in late summer.

FIG. 11.—A potato affected with dry-rot following late-blight. External view.

Powdery Dry-Rot.

Outside of the regions where the late-blight occurs, storage rot of potatoes is caused principally by three or four species of Fusarium which attack the potato through wounds or follow the wilt fungus. The most serious of these is one most prevalent in the Western States, called the powdery dry-rot (*Fusarium trichothecioides* Wr.), illustrated in figure 13. While this is primarily a wound parasite, it often spreads very rapidly in potatoes in transit to market or stored under unfavorable conditions. It does not attack the growing plant to any extent, but if partly affected potatoes are planted, the fungus lives through the summer and attacks the next crop after it goes into storage. For this reason all potatoes showing any signs of decay should be rejected for planting. The crop should be stored at a low temperature immediately after digging, before any heating can take place. The greatest care should be taken to avoid bruising the potatoes in digging and handling. Storage cellars should be well cleaned and disinfected.

FIG. 12.—A potato affected with late-blight dry-rot. Cross section.

Forms of external dry-rot, caused by other fungi closely related to the foregoing, are not infrequent on injured tubers wherever

potatoes are grown. Care in handling and the rejection of partly decayed potatoes for planting are the best preventive measures.

OTHER TUBER DISEASES.

Internal Brown-Spot.

When dry, brown spots are scattered through the flesh of the potato and are not restricted to the vascular ring, we have a disease known as internal brown-spot. (Fig. 14.) This is not a parasitic trouble, for the spots consist of dead cells free from bacteria or fungi. Internal brown-spot is associated with dry soils or lack of water at some period during the growth of the tuber and is worse on some varieties than on others. It may indicate that the variety is not adapted to the soil. This disease is not carried in the seed. Its occurrence depends upon soil and climatic conditions. The question has, however, never been settled whether affected seed will produce as large a crop as healthy seed, and many would reject such potatoes on general principles.

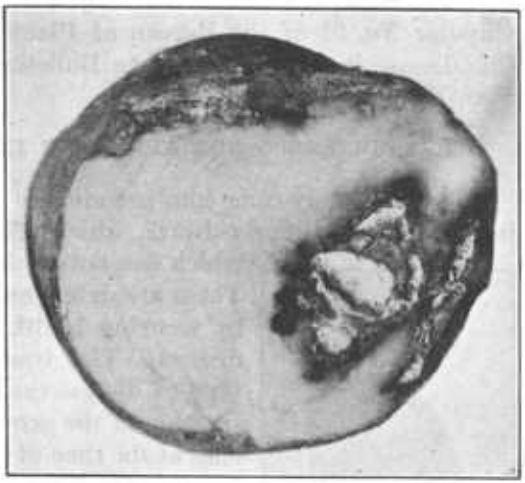

FIG. 13.—A potato affected with powdery dry-rot. Section through a diseased tuber.

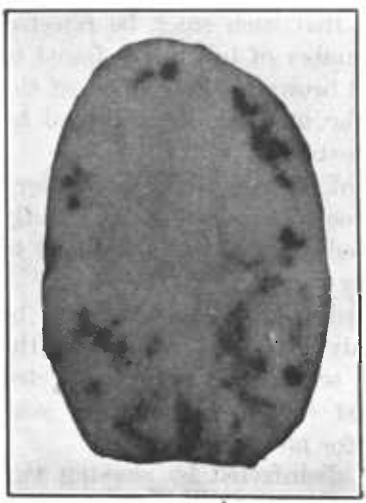

FIG. 14.—A potato affected with internal brown-spot.

Eelworm.

In the Western States and to some extent in the South the eelworm, or root-knot nematode (*Heterodera radicicola.* (Greef) Mül.), must be reckoned with as a factor in potato culture. This trouble is due to a minute worm which attacks the tubers, causing a knotty and irregular appearance. (Fig. 15.) When cut into, such potatoes show a line of glistening spots just beneath the skin. (Fig. 16.) All such pota-

toes are unfit for planting and constitute a serious danger, in that they may carry the pest from one farm to another. Infested soils must be rotated in crops not subject to this pest, as described in Circular No. 91 of the Bureau of Plant Industry. The control of this disease is further treated in Bulletin No. 217 of the Bureau of Plant Industry.

DISEASES NOT APPARENT IN THE TUBERS.

There has lately come into prominence a group of diseases, including leaf-roll and curly-dwarf, which are carried in the tubers but which can not be detected by tuber inspection. These are dangerous troubles, combatable only by securing healthy seed stock from another district. The freedom of a stock from this type of disease can be determined only by inspection of the growing crop, preferably twice, once at the time of blooming and a second time shortly before the harvest.

FIG. 15.—A potato affected with eelworms, showing the irregular, knotted appearance of the outside of the tuber.

THE CHOICE OF SEED POTATOES.

Summarizing the suggestions in the preceding discussion it is urged that all seed stock be carefully inspected before purchase or use for planting and that such stock be rejected if any material number of tubers are found to have the stem-end browning, indicative of the wilt diseases or the internal decay caused by the black-leg parasite.

Dry-rot, either of the late-blight or powdery type, unfits potatoes for planting, and badly bruised or wounded potatoes are also likely to give unsatisfactory results.

Eelworm-infested potatoes should never be planted. The only means of restricting the spread of silver scurf is to reject affected potatoes. Any suspected cases of wart disease or powdery scab should be sent to a competent authority for identification.

All potatoes for planting should be disinfected by soaking two hours in a solution of 1 pint of formaldehyde to 30 gallons of water, and after treatment should not be allowed to come in contact with old sacks or barrels that might reinfect them. A formaldehyde-gas treatment, adapted to the disinfection of entire cellars at one time, has been tried, but for the average grower the treatment by soaking is to be preferred.

Finally, the purchaser of seed should insist on being supplied with high-grade stock, to the end that the producer will be forced to control preventable diseases where the seed stock originates.

WHAT FORM OF LEGAL REGULATION OF THE SEED TRADE IS BEST?

With the increased losses from potato diseases and the growing realization of the danger in diseased seed stock there have been several plans suggested for the improvement of conditions through legal enactments involving inspection, treatment, or the prohibition of the shipment of diseased stock. However desirable these may be in theory, their application to actual trade conditions is full of difficulty, and unwise or impracticable restrictions might involve both shipper and purchaser in expense or loss disproportionate to the advantage gained. The vast quantity of potatoes used for planting makes official inspection costly and treatment still more so. The short period of digging in the North compels the greatest haste in all farm operations on account of the imminent danger of freezing weather. It must further be recognized that many of the potato diseases are not familiar to the growers and dealers and might be overlooked in their incipient stages. The most easily detected disease—the scab—does not destroy the value of potatoes for seed if disinfection be practiced.

FIG. 16.—Longitudinal section of a potato affected with eelworms.

One form of regulation suggested provides for a State or local quarantine against all potatoes not treated with formaldehyde at the point of origin. This is hardly feasible in commercial practice for the reasons already cited and because black-leg, wilt, and other troubles are not reached by the treatment, while reinfection by the scab might occur in the cars, ships, or warehouses during shipment.

The evidence shows that healthy potatoes can best be secured by growing healthy potatoes, and not by inspecting, fumigating, or quarantining diseased stock. The progressive seed grower can eliminate or control nine-tenths of the diseases described in this bulletin,

and will do so if his market requires it and if a premium is paid for the extra labor involved. The method of tuber-unit selection described by Stuart in Farmers' Bulletin 533 will greatly assist in the elimination of many of these diseases from the field. A closer connection between the northern grower and the southern grower would be highly advantageous.

FIELD INSPECTION AND CERTIFICATION.

A plan is suggested whereby the freedom from disease and the varietal purity of seed potatoes may be certified by an officially appointed inspector or committee. This would work to the benefit of both producer and purchaser, for the producer would be able to secure a ready sale at an adequate price for his high-grade crop, while the purchaser would be assured of an opportunity to procure healthy stock. This inspection should be made in the field while the crop is growing. It should be voluntary or at the request of the grower, who should bear the expense. This expense, when divided by the number of bushels produced, would be small and much less than the increased value of the product.

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